

Applied Reverberation Modeling Workshop

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LONG TERM GOALS

Improve accuracy, fidelity, and speed of reverberation models for modeling, simulation, training and sonar system performance predictions.

OBJECTIVES

The objective is to achieve more efficient transitions from the 6.1 basic research community to the applied modeling community.

APPROACH

The approach is as follows: 1) develop enhanced understanding of 6.2/6.3 needs within the 6.1 community (emphasis on physics rather than signal processing); 2) develop long-term interactions between 6.2/6.3 and 6.1 researchers (addressing current/future Navy needs through FNC or alternate paths) and 3) identify topics that require long-term 6.1 basic research.

WORK COMPLETED

In FY10 the PI:

1. conducted site visits to various Navy laboratories and sponsors to determine key deficiencies in reverberation modeling
2. conducted collaborative modeling

RESULTS

The PI chaired the Applied Reverberation Modeling Board, consisting of Roger Gauss (NRL), John Perkins (NRL), Steven Stotts (ARL-UT), Dajun Tang (APL-UW), Eric Thorsos (APL-UW) and Tom Yudichak (ARL-UT), (originally David Knobles was the ARL-UT representative).

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Site Visits

The substantial majority of the effort went toward the site visits (with the Board) with the intent to understand key modeling shortfalls in the operational community. The initial focus was on mid-frequency active systems but also included air deployed and submarine systems. Sites visited included

- ONR HiFAST FNC (a major transition path)
- ARL-UT
- SPAWAR
- CNMOC/NAVO
- Sensor Optimization Working Group (SOWG)
- NUWC
- APL-JHU
- NSWC-Carderock
- NAVAIR

The visits provided important insights into deficiencies in supporting environmental databases, component models (e.g., boundary reflection and scattering models) and the reverberation calculation itself. The visits also provided a basis for developing long-term interactions between the 6.1 and 6.2/6.3 communities.

Collaborative Modeling

The original approach called for an Applied Reverberation Modeling workshop in FY10. However, the modelers supporting the CASS and ASPM models did not have fiscal support to perform the required modeling or attend a workshop. Instead, a collaborative modeling exercise was designed in order to foster interactions between the 6.1 and 6.2/6.3 communities. One test case that was explored was the Acoustical Society of America (ASA) wedge benchmark (see [1]) with a penetrable lossy bottom. While the ASA benchmark was defined at 25 Hz and for propagation only, the collaborative modeling was performed at 1000 Hz and included both propagation and reverberation with the receiver on a transect perpendicular to the wedge (3-D effects were ignored). The ASTRAL/ASPM models were run by Kevin Williams (APL-UW/ONR) with guidance by Tony Eller (OASIS) and an energy flux (EF) and parabolic equation (RAM) models, run by the PI. The interest was in determining how the operational models (ASTRAL/ASPM) performed in a sloping environment. ASTRAL is extremely fast and reasonably accurate for this case, under-predicting the TL by a few dB (see Figure 1). It is believed that this is due to the fact that it ignores the effect of bottom slope on the reflection coefficient.

Reverberation comparisons are shown in Figure 2, where the energy flux solution can be thought of as an approximate benchmark. Given that for reverberation the two-way (e.g., upslope and downslope for the upslope case) propagation errors from neglecting bottom slope are roughly self-cancelling, it is expected that ignoring bottom slope for the scattering kernel (Lambert's Law) would lead to an under-predicting the reverberation upslope and vice-versa downslope. This effect is indeed observed in Fig 2. What was somewhat surprising is that the ASPM reverberation for constant depth has a 3-4 dB error at 10 km. The source of this discrepancy is under investigation.

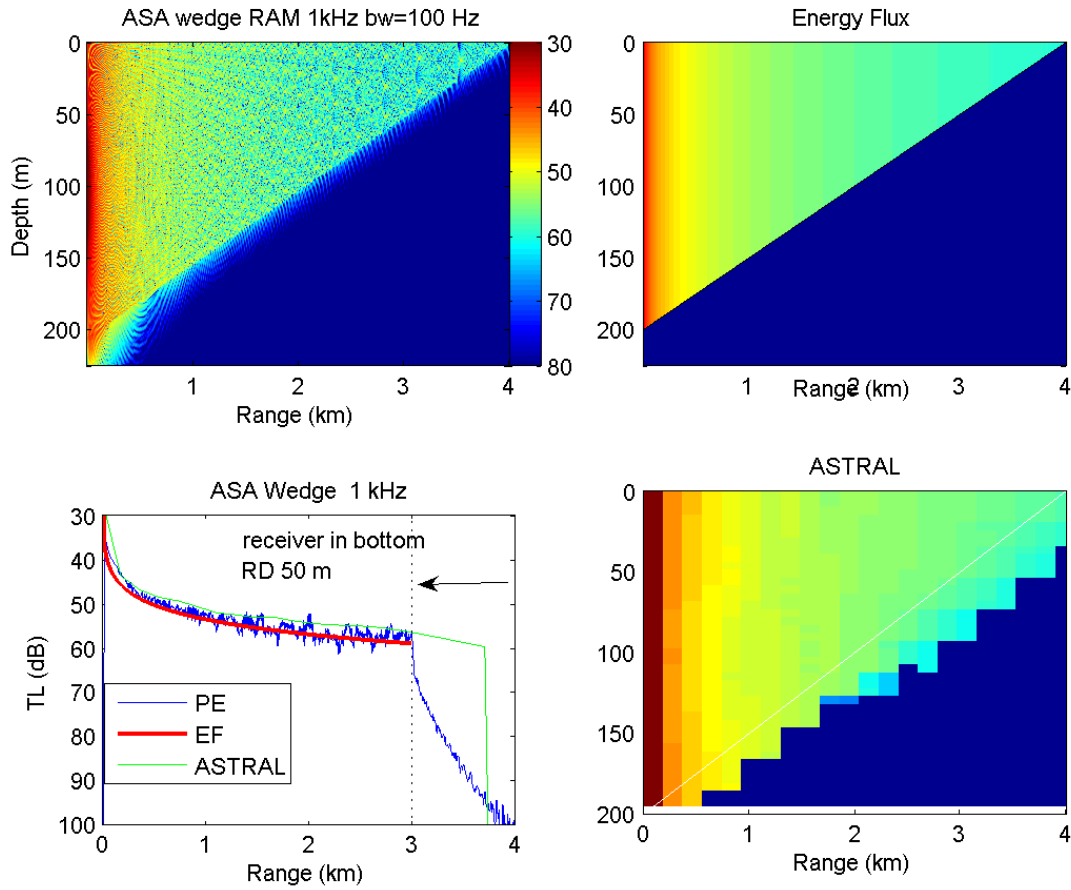


Figure 1. Comparison of RAM, energy and ASTRAL models for the ASA wedge problem at 1000 Hz. ASTRAL (runs performed by Kevin Williams) is extremely fast, and reasonably accurate for this case.

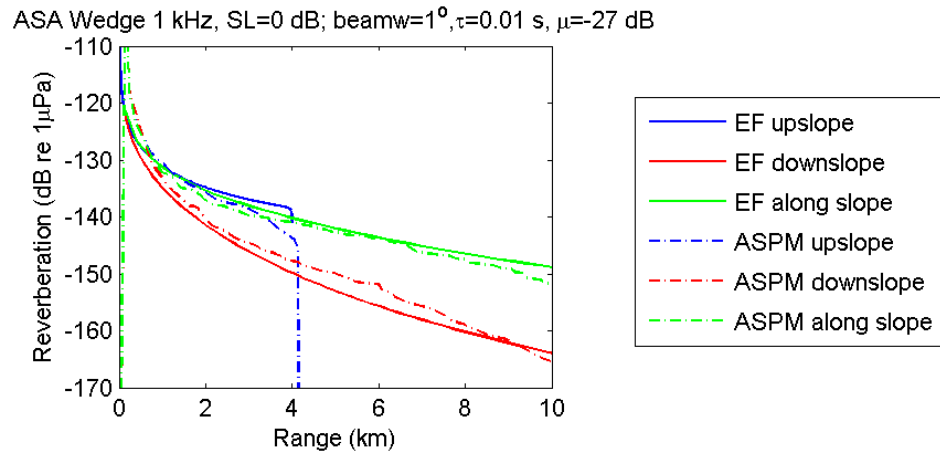


Figure 2. Comparison energy flux and ASPM models for the ASA wedge problem at 1000 Hz. ASPM (runs performed by Kevin Williams) differences with EF are probably due to ignoring local slope.

IMPACT/APPLICATIONS

It is anticipated that improved understanding of the 6.2/6.3 modeling issues by the 6.1 community will lead to enhanced transition of modeling research from the 6.1 community. For example, 6.1 research may provide valuable underpinnings for quantitative understanding of fidelity/speed trade-offs that are crucial to simulation and training requirements.

RELATED PROJECTS

The ONR-SPAWAR Reverberation Modeling Workshop is a closely related project that was intended to foster interaction primarily within the 6.1 community and develop benchmark solutions to canonical (principally) shallow-water reverberation problems.

REFERENCES

[1] F. B. Jensen and C. M. Ferla, Numerical solutions of range-dependent benchmark problems in ocean acoustics, J. Acoust. Soc. Am., 87, 1499-1510, 1990.